

# PRINCIPLES OF INFECTIOUS DISEASE EPIDEMIOLOGY

## MODULE I – INTRODUCTION TO EPIDEMIOLOGY

*This outline is provided as an aid to the student. It contains only the basic content of the module. To view the supporting material such as graphics, examples, etc. please see the module itself.*

### I. INTRODUCTION

#### A. What is the Purpose of Epidemiology:

- to better understand the burden and causes of health problems in human populations, and
- to make changes that decrease risk and improve health.

#### B. Epidemiology is comprised of a set of tools, including:

- Scientific methods for study/research
- Techniques for collecting and organizing information
- Information about the biological basis of health and illness
- Information about human behavior that affects health
- “People skills” needed to gain cooperation and gather solid information

#### C. Epidemiology can be applied to any aspect of human health, including:

- all types of diseases
- impairments
- disabilities
- injuries
- the utilization and outcomes of health services, and even
- good health.

#### D. Epidemiology has been used to study these conditions and many more:

- West Nile Virus infections
- Sexually transmitted diseases and HIV
- Surgical wound infections
- Hip fractures
- Childhood malnutrition
- Pertussis (whooping cough)
- Schizophrenia

#### E. Epidemiology can help us identify and understand the factors that influence the emergence, severity, and consequences of health problems. Examples include:

- tobacco use and lung cancer
- physical activity and heart disease
- diet and longevity
- lead exposure and developmental disabilities

- seat belt use and motor vehicle injuries/deaths
- childhood vaccine initiatives and child mortality
- statin drugs and outcomes of atherosclerotic heart disease

**This course will concentrate on the use of epidemiology to understand, prevent and control infectious diseases.**

#### **F. Infectious diseases:**

- Are caused by micro-organisms
- Are transmitted to humans from other humans, animals or the environment
- Usually follow recognizable patterns of symptoms, timing, etc.
- Evolve over time as new organisms emerge and human behavior and environments change

**G. This module is designed to prepare public health workers to meet the following objectives:**

1. Define key epidemiologic terms
2. Describe at least five factors that significantly influence the incidence and distribution of a disease in a human population
3. Describe the modern approach to epidemiology

## **II. KEY EPIDEMIOLOGICAL TERMS**

**A. EPIDEMIOLOGY** is derived from three Greek root words:

epi – on, upon  
 demos – people  
 logy – study

Epidemiology is, thus, the study of what is upon the people. **In modern terms, it is the science of the distribution of disease and its determinants (causes).**

Epidemiology is also a **process** that uses the facts at hand as clues to point to new knowledge and solutions. Epidemiologists have been called “disease detectives” and “medical sleuths” for this reason.

**B. Three key terms are used to describe basic patterns of infectious disease occurrence.** The terms are defined by the American Public Health Association (APHA) as:

**Endemic:** The habitual presence of a disease within a given geographic area; may also refer to the usual prevalence of a given disease within such an area.

**Epidemic:** The occurrence in a community or region of a group of illnesses of similar nature, clearly in excess of normal expectancy, and derived from a common or from a propagated source.

**Pandemic:** A worldwide epidemic.

**Endemic disease levels** are measured by ongoing surveillance systems. Some fluctuations usually occur.

**The transition from endemic to epidemic** can happen in days, weeks, months, or even years, depending on the disease. It may be hard to tell when the shift begins.

**There are parallel terms referring to disease patterns in animals that may affect humans:**

**Zoonosis:** An infection or an infectious disease transmissible under natural conditions between vertebrate animals and man (APHA).

**Enzootic:** “Endemic” among animal populations

**Epizootic:** “Epidemic” among animal populations

**C. The term epidemiology is used to refer both to:**

A method of study of diseases, and

A body of knowledge about the natural history of a disease

The natural history of a disease is a description of how that disease “behaves” and what factors affect its incidence and distribution. Here is a partial list of such factors:

1. Biological
2. Geographic
3. Nutritional
4. Meteorological
5. Social
6. Cultural
7. Religious
8. Behavioral
9. Economic
10. Historical
11. Political
12. Technological

**Example:**

**“The Epidemiology of Measles” includes:**

<b>Factor</b>	<b>Example</b>
Causative organism	Measles virus
Host	Humans
Mode of transmission	Airborne droplets and direct contact with secretions
Incubation period	About 10 days, range 7-18 days from exposure
Period of communicability	From a few days before onset of illness to 4 days after the appearance of the rash
Usual symptoms	Fever, conjunctivitis, coryza, cough and blotchy red rash
Complications	Otitis media, pneumonia, croup, diarrhea and encephalitis
Mortality rate	2-3 per 1,000 cases in USA; 3-5% in developing countries

*Epidemiologic methods were used to compile most of this information.*

### III. EVOLUTION OF EPIDEMIOLOGY

Human beings have always sought to understand and explain the occurrence of disease and death.

#### A. Supernatural Causation

- Throughout most of human history, people believed in the supernatural as the cause of illness.
- Individuals and communities who became ill were thought to have angered the gods or spirits, or to be victims of their enemies' magic.
- Such beliefs are still held today, even in otherwise modern societies.

#### B. Environmental Explanations

- Hippocrates was the first to suggest that disease is caused by environmental elements, around 400 B.C.E.
- From 400 B.C.E. until the mid-19<sup>th</sup> century, many theories were developed to explain infection.
- Most of these theories were based on the concept of miasmas. Contagious matter was thought to create a gaseous form, a miasma, which spread infection through the atmosphere.

#### C. Host Factors

- Edward Jenner, in 1796, introduced the idea of host resistance to explain why some people were immune to smallpox.
- Peter Panum, in 1846, took this idea further when he studied measles in the Faroe Islands. The islanders had not been exposed to measles in 70 years, and many otherwise healthy adults died.
- By contrast, in mainland Denmark all were exposed to measles in childhood, and adult deaths from this disease were rare.

#### D. Toward a Modern Approach

##### I. John Snow, a British scientist, made the greatest strides toward modern epidemiology in the 19<sup>th</sup> Century.

- At that time, infectious diseases were the leading causes of death.
- Up to half of all children died before the age of five, mostly due to infectious diseases.
- a. Snow's first study was conducted in 1848 when an epidemic of cholera hit the Golden Square area of London.
  - Even before bacteria were discovered as a cause of disease, Snow was able to stop devastating outbreaks by observing and recording information about the distribution of the disease.
  - Snow was working from a theory that water had something to do with the spread of cholera.
  - In the Golden Square area, most people got their water from public pumps.

- Snow's first step was to gather information about the cholera patients in the area, and record their residence or place of work.
    - He developed a spot map that showed the distribution of cases in relation to the water pumps.
    - Snow investigated all the pumps in the area.
      - One pump was so grossly contaminated that people had avoided its use.
      - One pump was in an out-of-the way location, and therefore not used much.
      - Many of the cholera cases were clustered around the Broad Street Pump.
      - When Snow checked with the families of the cholera victims, he confirmed that they all used the Broad Street Pump.
  - Snow showed that by studying the distribution of cases, a source of infection could be found that explained the pattern. **He then took action to stop the epidemic, by having the pump handle removed.**
- b. Snow did more pioneering work during another cholera outbreak in 1854.
- This outbreak affected several areas of London that depended on water hauled in by wagon.
    - Two companies, the Southwark and Vauxhall (S&V) Company and the Lambeth Company, did the hauling.
    - Some districts were served mostly by S&V, other districts mostly by Lambeth, and some districts were served by both.
  - Snow compared the number of cholera deaths in the various districts.
    - Snow realized that the raw numbers of deaths could not tell him much.
    - If some districts had many more people than others, they couldn't really be compared.
    - So he collected population figures from the most recent census and calculated cholera death rates per 1,000 people.
  - The rates paint a very clear picture.
    - The death rate was 22 times higher in the districts served only by S&V, compared with those served only by Lambeth.
  - Further investigation showed that both companies were drawing their water from the Thames River.
    - However, S&V pulled water from a point just downstream from a major sewer outlet, while Lambeth drew theirs upstream from the outlet.
  - Snow had shown conclusively that water could serve as a vehicle for transmitting infection. He also showed that humans could intervene, in this case by changing the location of the S&V water intake.

**2. William Farr, the father of modern vital records, was another important figure in the development of epidemiology. His contributions include:**

- establishing the first registry of births and deaths in the 1830s.
- advancing population-based surveillance.
- distributing reports that led to public health interventions.

Example: Mortality in Liverpool, 1843. The median age of survival in Liverpool in 1843 was 6 years, compared with an average of 45 in the rest of England. This revelation led to policy and law changes to improve sanitation.

### 3. Establishment of the Germ Theory (1860 to 1890)

- Studies by Louis Pasteur and Robert Koch firmly established the germ theory.
- Attention and research efforts shifted
  - to biological agents, and
  - away from the environment or host resistance.
- This shift happened in spite of Pasteur's warning that the role of the environment was more important than that of the agent.
- Snow's work was not appreciated or expanded upon until the years after World War II.

### 4. Modern Epidemiology

- The **modern approach** in describing an infectious disease focuses on:
  - the interaction of the disease agent,
  - the host, and
  - the environment.
- The disease agent, the host, and the environment interact dynamically to produce disease. All three of these are constantly changing:
  - **Disease agent:** Microorganisms adapt to changing conditions, including human control efforts such as antibiotics.
  - **Host:** Human populations are constantly growing and moving as people age, travel, and migrate into new environments.
  - **Environment:** Changes occur locally and globally, both naturally and through human intervention.

(i) Disease Agents: There are many "agents" of disease and disabilities, including:

- nutritional components such as vitamin deficiency diseases and obesity.
- physical forces such as fire, radiation, and chemicals.
- biological agents such as bacteria and viruses.

In this course, however, we will be focusing on biological agents that will be covered more fully in other segments of the course.

(ii) Host Factors: Some host factors that influence susceptibility to disease are:

Sex  
Race  
Age  
Occupation

Nutrition  
Heredity  
Marital status  
Socioeconomic status  
Religious and social customs  
Immunization history  
Previous history of disease

(iii) Environmental Factors: Many aspects of the environment influence both an agent's survival and growth, and a host's contact with a disease agent. Some of the environmental factors are shown below.

Temperature  
Humidity  
Altitude  
Water  
Radiation  
Pollution  
Housing conditions  
Food/milk

**Each disease is influenced by a particular set of factors.**

**Examples:**

- 1) Some foodborne diseases, such as salmonella, are highly dependent on environmental factors such as cross-contamination and cooking/holding temperatures.
- 2) The spread of measles is influenced by immunization status, but also by housing conditions and nutritional status.
- 3) Disease history is a big factor with some diseases, such as hepatitis A, that confer lifetime immunity after infection.
- 4) Many other diseases can cause repeated infections in the same individual, for example gonorrhea, shigellosis and malaria.
- 5) Some diseases are transmitted to humans only through arthropod vectors such as mosquitoes, ticks or lice.
  - These disease organisms may have complex lifecycles that pass through several different hosts.
  - For example, the spirochete that causes Lyme Disease is transmitted to humans from certain ticks, but its lifecycle includes rodents and large mammals such as deer.
  - Vectors are subject to agent, host and environmental factors too.

**Epidemiology gives us tools to learn** about how these factors interact to produce a particular disease in a particular population. Good epidemiology is most critical when investigating an outbreak or the emergence of a new disease - some of the most important tasks of the field epidemiologist.

**A team approach** is almost always used in epidemiologic investigations. The range of experts needed depends on the disease and the setting, but usually includes:

- Epidemiologists
- Medical professionals (physicians, nurses)
- Laboratory scientists
- Statisticians
- Environmental specialists

## **Summary**

Epidemiology is a set of tools for understanding the burden and causes of health problems in human populations, so that we can make changes that decrease risk and improve health.

Epidemiology can help us identify and understand the factors that influence the emergence, severity, and consequences of health problems.

Epidemiology is defined as the science of the distribution of disease and its determinants (causes).

Human beings have always sought to understand and explain the occurrence of disease and death. The modern approach to epidemiology has developed within the past 150 years.

The modern epidemiological approach to infectious diseases focuses on the interaction of the disease agent, the host and the environment.